LF61
Low-dimensional strongly correlated electron systems, spin-Hall effect and nanoscale science and technology

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2 Research Activity

We investigated the comparative field emission from vertically aligned few-layer graphene and carbon nanotubes. In collaboration with Yerevan State Univ., we studied the fermionic condensate in a conical space with a circular boundary and magnetic flux, quantum ring models and action-angle variables, as well as the external field influence on semiflexible macromolecules: geometric coupling. In collaboration with IHEP Protvino we studied the uses of crystals in connection to accelerator physics.

We carried out a study of nanojunctions as logic operators for the spintronics, of spin filtering effects in a one dimensional artificial lattice with ring geometry subject to Rashba coupling, of single spin-qubit rotators based on nanojunctions using a semiclassical path integral approach interaction. Also spin phases and currents in ring shaped one-dimensional quantum dot arrays, was investigated, as well as the role of quantum wires as logic operators, in connection to the XNOR and NOR gate response in a ballistic interferometer. Landau levels and edge states in a cylindrical two-dimensional electron gas in a semiclassical approach were studied.

A modal analysis of piezoelectric bodies with voids was also the object of our research.

We have continued our work on a rigorous derivation of a real space full-potential multiple-scattering theory (FP-MST), valid both for continuum and bound states, for the calculation of core-level synchrotron radiation spectroscopy as applied to many interdisciplinary problems in condensed matter physics. We have been able to show that, contrary to the common belief in the literature, multiple scattering theory converges absolutely, so that the angular momentum truncation procedure is well founded. In this way we have solved a problem tha had been staying around for almost thirty years.

We have started the implementation of codes, based on our Full Potential MST, to calculate in real space properties of the ground state of molecules and in general clusters of atoms in a self-consistent way, in order to obtain self-consistent charge densities, the position of the Fermi level, the equilibrium atomic positions and other useful quantities both for ground state and continuum spectroscopies.

In collaboration with the ICMA Institute in Zaragoza (Spain), a resonant x-ray scattering study at the Mn K-edge and Tb L3-edge of TbMnO3 was performed to investigate the local distortions responsible for the ferroelectricity. TbMnO3 perovskite is indeed an interesting representative of those materials, of great technological importance, where antiferromagnetism (AFM) and ferroelectricity coexist at low temperatures.

In collaboration with the Univ. of Bourgogne-Dijon we have extended the multichannel MS program developed by P. Kruger in Dijon to complex algebra, in order to implement contour integration for the multichannel Green's Function and describe electronic correlation not only in the excited state but also in the ground states of molecules and clusters of atoms. It is hoped that this approach will cure the deficiences of the current Density Functional Theory (DFT) programs and go beyond the Dynamical Field Theory Approach (DMFT) in treating electronic correlations in solids.

Particle-particle response function as a probe for electronic correlations in the p-d Hubbard model, time-dependent transport in graphene nanoribbons, magnetic moments in biased quantum circuits, were also important topics of interest for our investigations, along with the dynamical Coulomb Blockade and the derivative discontinuity of time-dependent Density Functional Theory. Lastly, we assessed the accuracy of Kohn-Sham conductances using the Friedel sum rule.

We organized, so far, ten Schools and Workshops on nanoscale science and technology, aiming to assess the current state of the art and stimulate research networking, held under the patronage of INFN and other institutions from both the public and private sectors. The most recent edition was Nanoscience & Nanotechnology 2010, Laboratori Nazionali di Frascati - 20-23 September 2010, http://www.lnf.infn.it/conference/nn2008/.

18 september 2010 Prof. Gerardo Iovane, associated INFN LNF within the LF61 project, was the recipient of the Leonardo Award for Scientific Research, owing to the results he obtained in research, innovation and technology transfer.

3 Conference Talks

1. P. Onorato, "Quantum wires as logical gates for nanoelectronics". Presented at the XCVI Congresso Nazionale SIF Bologna, 20-24 September 2010.

2. P. Onorato, "Quantum interferometers patterned in Quantum Wires: Logic gate responses". Presented at Nanoscience & Nanotechnology 2010 Laboratori Nazionali di Frascati 20-23 September 2010.

3. L. Coderoni, "Mechanical and electrical characterization of nanocomposites coatings for electronic circuits", Presented at Nanoscience & Nanotechnology 2010 Laboratori Nazionali di Frascati 20-23 September 2010.

4. S. Bellucci, "Carbon nanotube based composites: Microwave probing towards electromagnetic shielding", Con. NANOSEA, Cassis, July 2, 2010.

5. S. Bellucci, "Effectiveness of microwave electromagnetic shielding in carbon based epoxy nanocomposites", Con. IRMMW-THz 2010, Rome, September 7, 2010.

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